IMAGE FORMING DEVICE AND METHOD

Inventor:

Douglas Gene Keithley

BACKGROUND

[0001]   This invention generally relates to laser printers
and more particularly, the present invention relates to
laser printers having selectable printing resolutions.

[0002]   Laser printers have become a de factor standard
appliance in the art of printing. Laser printers print
by depositing, using electrostatic charges, very finely
manufactured toner on selected portions of print media
such as paper then fusing the toner onto the paper
using heat and pressure. Research in the laser
printing technology resulted in the development of
laser printers having resolutions in excess of 600 by
600 DPI (dots -per-inch) or even more. For such a
printer, characters and marks on each page are defined
by a grid of pixels, each pixel being $1/600^{th}$ inch on
each side.

[0003]   Basic operations of a laser printer are discussed
with reference to Figure 1. Figure 1 is a simplified
schematic diagram of a laser printer 10. The laser
printer 10 receives *print data* 12 from a host computer
14 connected to the laser printer 10. A processor 16
of the laser printer 10 formats the print data 12.
That is, the processor 16 is adapted to process the
print data 12 to produce *pixel data* representing a grid

of pixels on a print medium such as paper. Often, each pixel is represented in the pixel data by one binary digit (a bit) with 0 assigned to one state (for example, off) and 1 assigned to another state (for example, on).

[0004]   Figure 2A illustrates a 12 pixel by 12 pixel sample grid 2 0 of pixel data. As illustrated, some pixels are in an on-state (for example, pixel 22) while other pixels are in the off -state (for example, pixel 24).

[0005]   For each pixel of the pixel data, the processor 16 translates the pixel value to a *pulse-width-modulation code*, and sends the pulse -width-modulation code to a controller circuit 18 which controls the operations of various electro -optical-mechanical devices 19 of the printer 10. The electro -optical-mechanical devices 19 include, for example, a laser, a mirror, a drum, corona wires, rollers, lamps, a fuser, and various sensors. The sample pixel grid 20, when printed on paper, can appear as illustrated in Figure 2B and forms a letter "A." As illustrated, in the present example, to form the letter "A," the print data 12 was formatted to pixel data including a grid of pixels having off -state (0) and on-state (1) values. Toner was applied to the print medium such as paper for the pixels represented by the on -states. Then, the toner is fused onto the paper using heat and pressure applied to the paper by a fuser.

[0006]   For convenience, the pulse -width-modulation code is referred to as a   *pcode* in this document. The processor 16 translates each pixel value into a pcode.

- 2 -

The pcode is a set of two values often designa ted (j, p) where j is the justification value and p is the pulse width value which correlates to the width of pigmentation that can be laid down for a particular pixel. The pcode is used because, in most laser printers, the placement of the toner particles can have a finer adjustment even within a single pixel. Such fine adjustments are possible through the use of narrow laser beams, fine mirror controls, and very small toner particles.

[0007]   For example, j can be set at 0, 1, 2, or 3 to indicate that the pigme ntation for a particular pixel should be left justified, right justified, centered, or split within the pixel. Further, p can range within a predetermined range of numbers for adjustment of the pulse width value. Typically, p can range from 0 to 31 to provide for 32 different widths of the pigmentation within a pixel with 0 indicating no toner applied, 31 indicating toner applied to the entire width, and all numbers between 0 and 31 indicating toner applied to a corresponding portion of the pixel.

[0008]   Figure 2C illustrates pcodes for a portion 26 of the sample grid 20. For the sample grid 20, the off - pixels such as the off -pixel 24 have the pulse width value of 0 which correlates to no toner applied to these pixels. For these pixels, the justification value is not relevant since no toner is applied. The on-pixels such as the on -pixel 22 have the pulse width value of 31 which correlates to toner applied to the entire width of these pixels. Also for these pixels, the justification value is not relevant since   the

entire pixel is covered.

[0009]   Other possible pcodes and their results as printed
pixels are illustrated in Figures 3A and 3B. As
illustrated, pixels 30, 32, 34, 36, 38, and 40 have
pcodes, respectively, of (0, 0), (0, 15), (1, 15), (2,
7), (3, 15), and (0, 31). Pixel 30, having the pulse
width value of 0, has no pigmentation within the pixel
30. For pixel 30 its justification value is
irrelevant. Pixel 32 has pulse with of 15 (which is 16
counting from 0, 50 percent of 32 possible values) and
justification code 0 (left justified). Accordingly,
left 50 percent 33 of the pixel 32 is covered. Pixel
34 has pulse with of 15 and justification code 1 (right
justified). Accordingly, right 50 percent 35 of the
pixel 34 is covered. Pixel 36 has pulse width value of
7 (which is 8 counting from 0, 25 percent of 32
possible values) and justification code 2 (centered).
Accordingly, center 25 percent 37 of the pixel 36 is
covered. Pixel 38 has pulse width value of 15 and
justification code 3 (split). Accordingly, 25 percent
of left side and 25 percent of right side (collectively
39) of the pixel 38 is covered. Pixel 40, having the
pulse width value of 31, the maximum value.
Accordingly, the entire width of the pixel 40 is
covered by the toner. For pixel 40 its j ustification
value is irrelevant.

[0010]   Generally, as illustrated in Figures 2A through
2C, each on -pixel is fully covered with pigmentation
and each off -pixel is left completely uncovered.
However, for certain characters or marks on the print
medium, such tech nique imposes limitations, lead to

- 4 -

undesirable results, or both.

[0011]   For example, it would be desirable to adjust or set the pcodes of certain pixels to vary print quality, to produce desired effects on the print medium, alleviate or eliminate unwanted results   , or a combination of these.

[0012]   One approach to vary print quality (for example to produce a draft quality document while reducing toner usage) is to use a single, predetermined pcode (rather than the translated pcode) for selected pixels. However, this appr oach is limited to using the same predetermined pcode irrespective of the context in which the pixel was selected. Thus, the predetermined pcode may not be the optimum, or even appropriate, pcode for the selected pixel. Further, such approach does not ad dress certain undesirable effects such as toner explosion.

[0013]   Toner explosion occurs during the fusing process. When the fuser applies heat and pressure to paper and toner on the paper, the toner melts and fuses with the fibers of the paper. During the fu sing process, the heat and the pressure generate gas and water vapor within the paper. Normally, such gas and water vapor leave the paper without interfering with the melting toner; however, certain patterns of toner prevent efficient ventilation of the g   as and water vapor leading to scattering of toner on the page resulting in a defective image. The current techniques are limited in their ability to eliminate such conditions.

[0014]   Accordingly, there remains a need for an improved method and apparatus to allev   iate or eliminate the

shortcoming of the current generation of printers.

SUMMARY

[0015]   The need is met by the present invention.
According to a first embodiment of the present
invention, an apparatus having a processor is
disclosed. The processor is adapted   to perform a
number of operations including operations to identify a
grid of pixels having a predetermined pattern of pixel
values; to obtain predetermined pcode grid from memory
for the identified grid of pixels; and to send the
predetermined pcode grid   to controller circuit for
printing.

[0016]   In a second embodiment of the present invention a
method of printing data on a print medium is disclosed.
First, print data is formatted to pixel data, the pixel
data including pixel values. Next, a grid of pixels
having a predetermined pattern of pixel values is
identified. Then, predetermined pcode grid is obtained
from memory for the identified grid of pixels.
Finally, the predetermined pcode grid is sent to
controller circuit for printing.

[0017]   Other aspects and advan   tages of the present
invention will become apparent from the following
detailed description, taken in conjunction with the
accompanying drawings, illustrating by way of example
the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]   Figure 1 is a simplified schematic view of a prior art apparatus;

[0019]   Figure 2A illustrates a 12 pixel by 12 pixel sample grid of pixel data;

[0020]   Figure 2B illustrates toner placement on a print medium for the sample grid of Figure 2A;

[0021]   Figure 2C illustrates pulse -width-modulation code values for a portion of the sample grid of Figure 2A;

[0022]   Figures 3A and 3B illustrate other sample pulse -width-modulation code values and resulting toner distribution;

[0023]   Figures 4A and 4B are simplified schematic view of apparatuses in accord ance with embodiments of the present invention;

[0024]   Figure 5 is a flowchart illustrating steps of one embodiment of the present invention;

[0025]   Figures 6A, 6B, and 6C illustrate sample pixel values, sample pulse   -width-modulation codes and corresponding toner distribution;

[0026]   Figures 7A and 7B, illustrate another sample pulse-width-modulation codes and corresponding toner distribution; and

[0027]   Figures 8A and 8B, illustrate yet another sample pulse-width-modulation codes and corresponding toner distribution.

DETAILED DESCRIPTION

[0028]   The present invention will now be described with
reference to Figures 1 through 8B, which illustrate
various embodiments of the present invention. As
illustrated in the Figures, relative sizes of various
portions, structures, or any combination of these are
exaggerated for illustrative purposes and, thus, are
provided to illustrate the general structures of the
present invention.

[0029]   As shown in the Figures for the purposes of
illustration, one embodiment of the present invention
is exemplified by an apparatus, for example a printer.
The printer has a processor adapted to identify a grid
of pixels having a predetermined pattern of pixel
values, obtain predetermined pcode grid from memory for
the identified grid of pixels, and send the
predetermined p code grid to controller circuit for
printing.

[0030]   The predetermined pattern is chosen such that it
is the pattern that may lead to undesirable toner
placement such as the toner explosion were the pixels
(of the grid matching the predetermined pattern)
translated to pcodes in the usual manner. The
predetermined pcode grid leads to desirable toner
placement. Using this technique, print quality, toner
usage, and color effects can be adjusted while
eliminating undesired results such as the toner
explosion problem.

[0031]   Figure 4A illustrates an apparatus 10a, for
example a printer 10a according to a first embodiment

of the present invention. The printer 10a of Figure 4A
includes components that are similar to corresponding
components of the printer 10 of Figure 1. For
convenience, components in Figure 4A that are similar
to corresponding components in Figure 1 are assigned
the same reference numbers. Similar but changed
components are assigned the same reference numbers
accompanied by letter "a." Different components   are
assigned different reference numbers. The apparatus
10a can be, for example, a printer, a copier, or a
multifunction appliance that typically include printer
function, copier function, or both.

[0032]   Figure 4B illustrates an apparatus 10b, for
example a printer 10b according to a second embodiment
of the present invention. The printer 10b of Figure 4B
includes components that are similar to corresponding
components of the printer 10 of Figure 1. For
convenience, components in Figure 4B that are similar
to corresponding components in Figure 1 are assigned
the same reference numbers. Similar but changed
components are assigned the same reference numbers
accompanied by letter "b." Different components are
assigned different reference numbers. The apparatus
10b can be, for example, a printer, a copier, or a
multifunction appliance that typically include printer
function, copier function, or both.

[0033]   The printer 10a of Figure 4A includes a processor
16a adapted or programmed to perform operations
implementing th e present invention. In the second
embodiment, the printer 10b of Figure 4B includes a
PCODE processor 21 adapted to or programmed to perform

operations implementing the present invention. The
PCODE processor can be a dedicated hardware for the
specific task of performing the operations implementing
the present invention and need not be a general
processor.

[0034]   The operations of the processors 16a and 16b,
PCODE processor 21, or both are explained using a
flowchart 50 of Figure 5. For convenience, in the
following discussion and in the Claims, the term
"processor" designates processors 16a, 16b, PCODE
processor 21, any one of these, or any combination of
these unless otherwise denoted. This is because the
processors 16a, 16b, PCODE processor 21, any one of
these, or any combination of these are sufficiently
malleable and configurable to perform any portion of
the operations implementing the present invention.

[0035]   Referring to Figures 4A, 4B, and 5, the processor
(16a, 16b, 21, or any one or combination of these)   is
adapted to receive and format a   *print data* 12 from a
host computer 14. These operations are represented in
the flow chart 50 as procedural step boxes 52 and 54.
The processor (16a, 16b, 21, or any one or combination
of these) formats the print data 12 . Step 54. That
is, the processor (16a, 16b, 21, or any combination of
them) is adapted to process the print data 12 to
produce *pixel data* representing a grid of pixels on a
print medium such as paper. Typically, each pixel is
represented in the pixel d ata by one binary digit (a
bit) with 0 assigned to one state (for example, off)
and 1 assigned to another state (for example, on).

[0036]   The processor (16a, 16b, 21, or any one or

- 10 -

combination of these) is adapted to examine the entire
pixel data. For each pixel , the processor (16a, 16b,
21, or any one or combination of these) examines its
surrounding grid of pixels to determine whether the
grid of pixels under examination matches a
predetermined pattern. Decision step 56. The
predetermined pattern can be any pattern.

[0037]   For example, Figure 6A show a sample grid of
pixels 70 under examination by the processor (16a, 16b,
21, or any one or combination of these). In the
illustrated sample, the sample grid of pixels 70 is a 6
pixel by 6 pixel grid having a 4-pixel-thick horizontal
"line." One the one hand, if the sample grid of pixels
70 is not identical to the predetermined pattern, then
no match is found. Then the processor (16a, 16b, 21,
or any one or combination of these) translates each
pixel value (either 0 o r 1) of the sample grid of
pixels 70 into its corresponding pcode. Step 60.
Typically the off -pixels are assigned pcode (0, 0)
indicating pulse width value of 0 for no coverage and
on-pixels are assigned pcode (0, 31) indicating pulse
width value of 31 f   or full coverage. The pcodes
corresponding to the sample grid of pixels 70 is
illustrated as a grid of pcodes 70p in Figure 6B. In
Figure 6B, the grid of pcodes 70p is illustrated using
larger size pixels (compared to size of the pixels of
the sample grid of pixels 70) so that the pcode values
for each pixel can be illustrated using legible font
size. Otherwise, the larger illustrated size is
irrelevant. The pcodes illustrated in Figure 6B is
then sent to the controller circuit 18 of Figure 4,

resulting in an area 70r on the paper that appears as
illustrated in Figure 6C. Step 62.

[0038]   On the other hand, if the sample grid of pixels 70
is identical to the predetermined pattern, then match
is found. Then the processor (16a, 16b, 21, or any one
or combination of these) obtains a predetermined pcode
grid from memory 17 of Figure 4. Step 58. The memory
17 can be one or more registers within the processor
(16a, 16b, 21, or any one or combination of these) as
illustrated. Alternatively, the memory 17 can reside
outside the processor (16a, 16b, 21, or any one or
combination of these). The predetermined pcode grid is
sent to the controller circuit 18 of Figure 4 for
printing. Step 62.

[0039]   The pcode for each of the pixels of the sample
grid of pixels 70 is found in   the corresponding
position within the predetermined pcode grid. A first
sample predetermined pcode grid 72p is illustrated in
Figure 7A and resulting toner pattern in Figure 7B.
Here, the off -pixels of the sample grid of pixels 70
are left unchanged, an d the on -pixels of the sample
grid of pixels 70 are assigned pcodes to produce a
checker-board patterned area 72r on paper. The
illustrated check-board pattern shows a 45 degree toner
placement.

[0040]   A second sample predetermined pcode grid 74p is
illustrated in Figure 8A and resulting toner pattern in
Figure 8B. Here, the off -pixels of the sample grid of
pixels 70 are left unchanged, and the on -pixels of the
sample grid of pixels 70 are assigned pcodes to produce
a higher frequency checker -board patterned are a 74r on

- 12 -

paper. Also, the illustrated check-board pattern shows
a toner placement angle at an angle other than 45
degrees.

[0041]   It is possible to configure the predetermined
pcode grid can have many different patterns resulting
in toner placement patterns, eac   h placement pattern
corresponding to its pcode grid pattern. For example,
predetermined pcode grid can have various half -toning
patterns, dots patterns, higher or lower frequency
patterns, at various angles, random patterns, or any
combination of these patterns. The predetermined pcode
grid can be patterned for various purposes. For
example, to save toner, to overcome toner explosion
problems, or both.

[0042]   Further, the pcode grid 72p or 74p of Figures 7A
and 8A need not be the exact size of or as large as the
sample grid of pixels 70 of Figure 6A. Note that for
the pcode grid 72p, the first two columns 73 repeat and
that for the pcode grid 74p, the first column 75
repeats. Indeed, the memory 17 can store only
sufficient columns, row, or columns and rows to   define
a *pcode grid pattern* that can be repeated to implement
the sample grid of pixels 70. For example, if a line
(having a sample grid of pixels) is 5000 pixels wide,
the replacement pcode grid need not be 5000 pixels
wide. In the examples given in Fig   ure 8A, the pcode
grid 74b only has to be one pixel wide since it does
not change in the horizontal direction. Pcode grids
can be implemented in any useful size, but sizes in the
order of several pixels, for example 3 -pixel grid or 8-
pixel grid, in column, in width, or both is sufficient.

- 13 -

The predetermined pixel grid can be determined using
any method. For example, Holliday algorithm can be
used to determine the predetermined pixel grid.

[0043]   For color printers utilizing a pcode grid for each
of its colors, t he present inventive technique can be
applied to each of the colors to produce a desired hue
or tone of the color. In such a case, different
predetermined pattern, predetermined pcode grid, or
both can be applied to each of the available colors.
That is, a first predetermined pattern and its
corresponding pixel grid applies to a first color and a
second predetermined pattern and its corresponding
pixel grid applies to a second color.

[0044]   As indicated by step 64 and loop 66, steps 56, 58,
60 and 62 discussed above are repeated until all the
pixels are processed.

[0045]   In the illustrated embodiment of Figure 4A, the
processor 16a of Figure 4A is adapted or programmed to
perform the functions of the steps of Figure 5. In the
illustrated embodiment of Figure 4B, the p rocessor 16b
of Figure 4B is adapted or programmed to perform some
of the functions of the steps of Figure 5 while the
PCODE processor 21 is adapted or programmed to perform
other the functions of the steps of Figure 5.
Specifically, functions illustrated as steps 56 through
64 of Figure 5 is implemented using the PCODE processor
21.

[0046]   From the foregoing, it will be appreciated that
the present invention is novel and offers advantages
over the current art. Although a specific embodiment
of the invention is described and illustrated above,

the invention is not to be limited to the specific forms or arrangements of parts so described and illustrated. For example, the print data can be compressed or decompressed during various processing steps as desirable. T he invention is limited by the claims that follow.